* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] the approach of starting an internal combustion engine -- it is -- an internal combustion engine's (1)'s crankshaft (2) accelerates to a rotational frequency (starting speed) required for an internal combustion engine's (1)'s starting at least -- having -- Therefore The rotator (5) acts on a crankshaft (2) through the gear connected in between directly. An electric machine means (4) is used. A crankshaft (2) is put on a predetermined crank angle (starting angle) by the electric machine means (4) for a starting process. An internal combustion engine (1) starts from this starting angle. Approach by which a part of energy [at least] required for starting is taken out from a capacitor capacitor (10).
[Claim 2] The approach according to claim 1 characterized by choosing the crank angle to which starting torque decreases as a starting angle.
[Claim 3] In the case of a four-cycle internal combustion engine, it is the approach according to claim 2 characterized by choosing the starting angle at the time of the termination of a compression cycle within the limits of just after the up dead point preferably.
[Claim 4] The approach according to claim 1 characterized by choosing the crank angle to which starting time amount decreases as a starting angle.
[Claim 5] The approach according to claim 4 which is characterized by choosing the starting angle at the time of initiation of an inhalation-of-air cycle in the case of an inlet-pipe injection type four-cycle internal combustion engine.
[Claim 6] The approach according to claim 4 which is characterized by choosing the starting angle at the time of termination of an inhalation-of-air cycle in the case of a direct injection four-cycle internal combustion engine.
[Claim 7] An approach given in any 1 term of said claim characterized by choosing a starting angle in consideration of which [of many cylinders] is added first in the case of a multiple cylinder internal combustion engine.
[Claim 8] An approach given in any 1 term of said claim characterized by adjusting a crank angle automatically the time of a halt of an internal combustion engine, or just behind that.
[Claim 9] An approach given in claim 1 characterized by adjusting a crank angle automatically just before starting process initiation, for example, a trigger being carried out by disconnection of a central lock in the case of an automobile thru/or any 1 term of 7.
[Claim 10] An approach given in any 1 term of said claim which will be characterized by charging a capacitor capacitor (10) with a dc-battery (9) in preparation for the following starting process if a trigger is carried out by the initiation angle accommodation command.
[Claim 11] The approach according to claim 10 that the charge threshold of a capacitor capacitor (10) required in order to start certainly is characterized by being chosen according to the temperature of an engine and/or the exterior.
[Claim 12] An approach given in any 1 term of said claim to which an internal combustion engine's (1)'s crank angle is characterized by being drawn from the angle location of the rotator (5) of an electric machine means (4).
[Claim 13] Internal combustion engine (1) It is the starter system of **. So that a crankshaft (2) may be accelerated to a rotational frequency (starting speed) required for an internal combustion engine's (1)'s starting at least An electric machine means by which the rotator (5) was combined with an

internal combustion engine's (1)'s crankshaft (2) through the gear connected in between directly (4), A means to detect and/or derive internal combustion engine's (1)'s crank angle, So that crankshaft (2) may be put on a predetermined crank angle (starting angle) for a starting process and a part of energy [at least] required for starting may be taken out from a capacitor capacitor (10) Control unit (11) which controls an electric machine means (4) Starter system which it has.
[Claim 14] Starter system according to claim 13 characterized by using detection of the rotator angle of an electric machine means (4) in order that a control unit (11) may derive an internal combustion engine's (1)'s crank angle.
[Claim 15] Starter system according to claim 14 characterized by building an integral angle-of-rotation sensor into the rotator (5) of an electric machine means (4).
[Claim 16] Starter system given in claim 13 characterized by an internal combustion engine (1) being the four-cycle diesel power plant or petroleum engine of the inlet-pipe injection type designed for passenger cars, or direct injection thru/or any 1 term of 15.
[Claim 17] Starter system according to claim 16 characterized by performing them for the first time after the injection and ignition in an internal combustion engine's (1)'s combustion chamber to a fuel reach starting speed.
[Claim 18] Starter system given in claim 13 to which an electric machine means (4) is characterized by being constituted as a starter/a generator thru/or any 1 term of 17.
[Claim 19] Starter system given in claim 13 characterized by an electric machine means (4) being the three-phase-alternating-current machine controlled by inverter equipment thru/or any 1 term of 18.
[Claim 20] Starter system given in claim 13 to which a capacitor capacitor (10) is characterized by being constituted as combination of an electric-type capacitor element and an electrochemistry type dc-battery element thru/or any 1 term of 19.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
This invention relates to the approach and the starter system for internal combustion engines which put an internal combustion engine into operation.
[0002]
It is known on experience that an internal combustion engine, for example, the internal combustion engine of an automobile, cannot start by himself. First, it must be made to have to start with the source of external power, and the so-called starter, and must accelerate even to an engine speed required for an internal combustion engine's starting. In this way, it begins and can run now by itself.

[0003]
By automobile, a dc-battery electric supply type direct-current motor is often used as an electric starter, and required starting torque is transmitted to an internal combustion engine's crankshaft through the drive pinion engaged to the gearing rim of a rotation disk. German patent DE 44 06 Starter system equipped with the electric Starter motor with which the rotator sat down to an internal combustion engine's crankshaft, and was further combined with 481A1 pivotable is described. With such equipment, the mass of the rotator of an electric machine means is used for coincidence also as an inertial mass.
[0004]
This type of advanced starter system is the Europe patent EP. 0 569 347 A2 and international public presentation WO It is stated also to No. 91/16538.
[0005]
An internal combustion engine's starting torque and minimum starting speed are especially dependent on an engine type, cylinder capacity, a number of cylinders, bearing friction, compression, preparation of gaseous mixture, and division temperature. It is important in which phase of a process of operation for the starting ease, for an internal combustion engine's compression therefore, there is a cylinder of the engine itself or an engine at the time of starting, and it is. For example, since compression of the cylinder which is in a compression cycle exactly makes too high torque counterpose a starter from the beginning of starting, it acts disadvantageously for starting behavior. Conventionally, this contractor was not fully taking the magnitude of this effect into consideration. Anyway, a well-known starter must be designed so that an engine-performance top internal combustion engine can start under all conditions.
[0006]
The technical problem of this invention is offering the approach of putting an internal combustion engine into operation more easily, and offering corresponding starter system.
[0007]
According to this invention, the above-mentioned technical problem is solved by the object according to claim 1 by the object of a publication of claim 13 at the point of equipment in respect of an approach again. The desirable operation gestalt of this invention is indicated by each subordination claim.
[0008]
By the approach of starting the internal combustion engine by this invention, an internal combustion

engine's crankshaft is accelerated to a rotational frequency (the so-called starting speed) required for an internal combustion engine's starting at least, therefore an electric machine means by which a rotator acts on a crankshaft through a gear in between directly is used. Furthermore, a crankshaft is used as predetermined crank angle location (below, a "starting angle" is called), i.e., predetermined crank angle, with an electric machine means for a starting process, an internal combustion engine is started from this starting angle, and a part of energy [at least] required for starting is taken out from a capacitor capacitor. Therefore, an internal combustion engine's proper starting process can be started from an advantageous starting angle, and moreover, it is not from a starter dc-battery altogether like [in the case of being usual], and electric power is supplied to at least a part from the capacitor capacitor which can bring about required electric startability ability quickly far from the conventional dc-battery. In addition, starting a problem does not have temperature sensitivity at very low temperature far low therefore rather than an electrochemistry type dc-battery, either is possible for a capacitor capacitor.

[0009]

Charge of a capacitor capacitor can be carried out by various approaches. One approach charges a capacitor capacitor from a starter dc-battery at every starting. It is desirable to use the command which carries out the trigger of the regulatory process of a crankshaft-starting angle for coincidence also as a signal for charging a capacitor capacitor from a starter dc-battery. If it does so, an internal combustion engine's starting can be carried out without a standby time.

[0010]

The starter system for internal combustion engines corresponding to this by this invention So that a crankshaft may be accelerated to a rotational frequency (starting speed) required for an internal combustion engine's starting at least An electric machine means by which the rotator was directly combined with an internal combustion engine's crankshaft pivotable through the gear in between, A means to detect and/or derive an internal combustion engine's crank angle, and the control unit which controls an electric machine means so that an internal combustion engine's crankshaft serves as a predetermined starting angle for a starting process, It has, the capacitor capacitor, i.e., the middle capacitor, which supplies a part of energy [at least] required for starting. The capacitor capacitor by this invention can be preferably made into the combination of an electric-type capacitor element and an electrochemistry type dc-battery element.

[0011]

In this invention, it has been recognized that the location of the crankshaft at the time of starting initiation is essentially important for an internal combustion engine's starting behavior. Based on it, this invention is based on the idea that a remarkable improvement of an internal combustion engine's starting behavior can be attained by improving also about the starting energy supply approach in the crank angle list in front of the starting process of a proper. It becomes possible to give torque required in order to adjust on a desired starting square in a high precision in the both directions of a crankshaft with the so-called crankshaft starter equipped with the rotator directly combined with the electric machine means, for example, a crankshaft, pivotable. If it does in this way, also when one or more cylinders of an internal combustion engine will be first compressed into coincidence, for example, a crankshaft location disadvantageous at the time of starting initiation is avoided, therefore it can start with a small starting output. In respect of equipment, starter system is in the condition which has recognized the momentary crank angle of the rotator of an electric machine means, and when required, it is equipped with the control unit controlled so that a crankshaft becomes a desired starting angle in consideration of the change gear ratio between a rotator and a crankshaft.

[0012]

The starter system by this invention can be advantageously used also for the inlet-pipe injection type or direct injection four cycle engine which was designed for example, for passenger cars also the case of petroleum engine, or in the case of the diesel power plant.

[0013]

With the desirable complete-change form gestalt of this invention, a crank angle to which the starting torque which should be given with an electric machine means at the beginning of a starting process becomes smaller than the case of well-known starter system as a starting angle is chosen. For example, since cylinder pressure reaches the maximum in an up dead point field mostly in the case

of the internal combustion engine which operates by the four-cycle formula, the compression which a starter should conquer in process of a compression cycle also increases. therefore, the next starting of a crank angle by the desirable deformation approach for four-cycle type internal combustion engines sake -- the last of a compression cycle -- it is preferably adjusted by the condition just after the up dead point. For this reason, a starter should just conquer an inhalation-of-air cycle [internal combustion engine] with comparatively weak compression. In order to generate sufficient starting output to conquer the following compression cycle moreover, a starter must carry out rotation near the after **** 2 rotation after starting initiation. Especially in the case of cold starting, this is advantageous.

[0014]

With another deformation gestalt of this invention, a crank angle to which starting time amount, i.e., time amount until an internal combustion engine starts from starting initiation, decreases to the minimum value as a starting angle is chosen. In the case of an inlet-pipe injection type four-cycle internal combustion engine, as for this, it is desirable to consider as the crank angle location which an inhalation-of-air cycle begins, and especially the overlap field between a discharge cycle and an inhalation-of-air cycle is desirable. On the other hand, in the case of a direct injection four-cycle internal combustion engine, it is desirable to make a crank angle location into the last of an inhalation-of-air cycle. In addition, when it has the gearing with a reference mark conventional sensor equipment and for crank angle detection with which an internal combustion engine consists of an inductive sensor, by choosing a starting angle within the limits of in front of the reference mark of angle-of-rotation sensor equipment, the regulatory process of a starting angle can be followed and starting time amount can also be shortened. in that case, detection of an angle of rotation -- a starting process -- it can carry out, without being behind for beginning exactly.

[0015]

When starting without delay can be carried out, this is useful to a traffic paint again, for example, raises the amenity of an automobilism. Furthermore, it becomes possible and is advantageous for the amount of total energies required for an internal combustion engine's starting to also become less, therefore to make smaller the dimension of a starter energy are recording machine.

[0016]

If the old explanation about this invention performs selection of a crankshaft-starting angle according to the cylinder lit by a multicylinder engine's beginning, it is applied like a single cylinder engine and a multicylinder engine. Usually, the sequence that a cylinder is lit one after another is given beforehand. However, according to the approach of this invention, in case the cylinder lit first at least is chosen, it is not from predetermined firing order, and it can also constitute so that the cylinder first lit according to the starting angle of the crankshaft which should be adjusted may be chosen.

[0017]

In case an internal combustion engine does switch-off of the ignition to an internal combustion engine, it is desirable to adjust to a starting angle advantageous to the next starting automatically with the electric machine means attached in the transmission just behind that by exerting braking or an acceleration operation on the crankshaft of an internal combustion engine while for example, an electric machine means' coasting. Or you may make it adjust a desired starting angle automatically first just before initiation of a starting process by for example making the front or back rotate the crankshaft of the internal combustion engine which an electric machine means is suspending to a desired starting angle. It is lost the starting angle adjusted once "is changed" into the period between a regulatory process and a starting process inconvenient by this. It is convenient especially to pull out a part of energy [at least] required for the drive of a starter from a capacitor capacitor in relation to the deformation approach mentioned at the end.

[0018]

In order to adjust the starting angle of a crankshaft, a momentary crank angle can be searched for and change of a crank angle can also be supervised with a control unit as compared with the value of a predetermined crankshaft-starting angle. Therefore, it is desirable to use the include-angle detection included in the electric machine means. Especially the thing for which the suitable angle-of-rotation sensor for a rotator, for example, the induction type, and the optical angle-of-rotation indicator of an

electric machine means is attached is desirable. However, the angle of rotation of an electric machine means can also be searched for from magnetic reflux of the rotator in the stator of an electric machine means. Since the rotator of an electric machine means is directly combined with an internal combustion engine's crankshaft indirectly through the gear, a crank angle is acquired by the easy conversion which took the change gear ratio into consideration directly.

[0019]

If required torque is supplied and desired crank angle accommodation can be carried out to a precision, as for direct current system, alternating current system, three-phase-alternating-current asynchronous system, or a three-phase-alternating-current synchronous system machine, all kinds of electric machine means fits the starter system of this invention fundamentally. As for the electric machine means of the starter system of this invention, it is desirable to consider as an electric machine means which accompanies as everlastingly [it is desirable and] as an internal combustion engine to function as a starter/a generator. Especially the rotating-magnetic-field type machine controlled by the electric machine means of the starter system of this invention with an inverter is desirable. The rotating magnetic field which rotate 360 degrees arise, and a "rotating-magnetic-field type machine" means the machine which drives an impeller. An inverter offers the alternating current to which reception, a frequency, the amplitude, and a phase can adjust the signal from a control unit freely. Such equipment is excellent in generating high torque, and fits both the hands of cut of a crankshaft.

[0020]

Though the development form and the description which are the above or are described about this approach below are natural, it is applied also about the starter system which corresponds clearly (the same is said of reverse).

[0021]

Below, it is based on an example and an attached schematic-diagram side, and other advantages, descriptions, and development forms of this invention are explained in detail.

[0022]

The starter system of drawing 1 is an automobile and an object for passenger cars. This starter system is equipped with the 4-cylinder internal combustion engine 1 which operates by the four-cycle formula, and tells torque to the driving wheel of an automobile through other parts (not shown) of a crankshaft 2, a clutch 3, and a transmission. The asynchronous three-phase-alternating-current machine is arranged the electric machine means 4 which works as a starter/an engine direct to a crankshaft 2 in this example, and here. This machine is equipped with the rotator 5 which sat down direct to the crankshaft 2 and was combined with it pivotable, and the stator 6 directed in an internal combustion engine's 1 housing. Such an electric machine means has high initial starting torque for a starter drive.

[0023]

With other operation gestalten (not shown), the rotator of an electric machine means, for example, a direct-current serial motor, is connected with the crankshaft 2 also through gearing through the gear between them depending on the case.

[0024]

In the example of drawing 1 , the alternating current or alternating voltage which the amplitude, a phase, and a frequency can adjust almost free is supplied to the coil of the stator 6 of the electric machine means 4 from an inverter 7. The direct-current intermediate-circuit inverter which consists of substantially DC-AC transducer 7a by the side of a machine, direct-current-voltage intermediate-circuit 7b by the side of a loading power source, and DC converter 7c is desirable. In addition, DC converter is combined with the automobile loading power source 8 and loading power-source long-term accumulation-of-electricity equipment 9, for example, the lead sulfuric-acid dc-battery of a conventional type. Into intermediate-circuit 7b, the capacitor capacitor 10 is connected a short-term accumulation-of-electricity component and here.

[0025]

The electric machine means 4 and an inverter 7 are designed so that torque required before starting initiation in both hands of cut may be brought about in order to adjust in a desired crank angle location, and a starting output required in order to carry out the direct drive of the crankshaft 2 by

required starting speed moreover at the time of starting can be brought about. The control device 11 of a high order controls a starting angle regulatory process and a starting process by controlling inverter 7, i.e., DC-AC ****, 7a and DC converter 7c. The control unit 11 of the electric machine means 4 receives the actual angle of rotation of a rotator 5 from the induction type angle-of-rotation sensor 12 installed in the interior of housing in relation to the rotator 5. Since the crankshaft 2 is directly connected with the rotator 5, the include angle of this measured rotator corresponds to the crank angle of a crankshaft 2.

[0026]

According to this invention, a starting process is prepared by the special approach. In case switch-off of the ignition after engine drive completion (for example, an automobile) is carried out, a control unit 11 controls the electric machine means 4 through an inverter 7 immediately after that so that a crankshaft 2 becomes the next starting in a convenient crank angle location. In order to adjust the electric machine means 4 to a desired crank angle in that case, braking or acceleration torque is alternatively told to the crankshaft 2 of the engine 1 under coast. In order to adjust to a desired crank angle while going in the case of the engine 1 under halt (for example, the "minimum impression torque"), electric-type equipment 4 can also be operated so that the front or back may be made to rotate a crankshaft 2 to a desired crank angle. This may not necessarily be the "shortest" path.

[0027]

It depends on an engine type, the number of gas columns, and firing order for the starting angle for starting the "optimal" crank angle, i.e., an internal combustion engine. Moreover, it is dependent on whether the small starting torque or the short starting time amount at the time of starting process initiation is desired for other starting behavior, for example, the next starting. In the 4-cylinder four-cycle internal combustion engine 1 as shows drawing 1 , the advantageous starting angle with small starting torque is in the field immediately after the up dead point of the cylinder lit first. Since both outside cylinders synchronize mutually in 4-cylinder straight engine, however it drives to the reverse sense with both inside cylinders, an advantageous starting angle is immediately after the up dead point of both internal combustion engines' 1 outside cylinder.

[0028]

The advantage of this adjusted starting angle is that the initial starting torque given by the starter machine 4 in order to start the following starting process is more remarkably [than well-known starter system] small. When an internal combustion engine 1 starts from this adjusted crank angle location, both internal combustion engines' 1 outside cylinder makes the electric machine means 4 supply at least the comparatively small torque to which a condition is mainly attached by friction. (Both inside cylinders) To the following compression cycle, the electric machine means 4 can supply sufficient (starting) energy to conquer compression to a system.

[0029]

The graph of drawing 2 illustrates how the "optimal" starting angle of starting torque small, for example can be determined about the engine type and driving gear of arbitration. Drawing 2 shows roughly the relation to crank angle phi of engine-speed n, when the torque of an electric-type starter machine is fixed. A condition is attached to a concrete wave by structure, and it depends for it on an engine type, cylinder capacity, the number of gas columns, bearing friction, a compression ratio, etc. especially. The field b where the rotational frequency n following the field a to which a rotational frequency n falls, and it increases is a combustion phase following the compression phase of a four stroke cycle engine, and it. Therefore, the greatest field also has compression in the field of an advantageous rotational frequency, and the activity phase of low compression of an internal combustion engine continues after that. If value phii of a crank angle is chosen, this corresponds to the small "optimal" crankshaft location of starting torque. Since both outside cylinders and both inside cylinders synchronize in the case of a 4-cylinder four-cycle internal combustion engine and it operates, starting angle phii becomes the location of about 180 degrees mutually. The corresponding property field is memorized by the control unit 11 of drawing 1 .

[0030]

The 1st deformation approach for starting the flow chart of drawing 3 by small starting torque is illustrated. At step S1, in case switch-off of the internal combustion engine 1 is carried out (for example, thing for which ignition in an automobile is cut), the command for adjusting a crankshaft-

starting angle immediately after that is executed. Subsequently, at step S2, direct measurement of a crank angle or measurement of the rotator angle of the electric-type starter machine 4, and detection of a crank angle are performed. Furthermore, a control unit 11 determines change of a required crank angle as the "optimal" starting angle of a request of a crankshaft 2 depending on the case, in order to adjust on a desired starting square. Subsequently, at step S3, a crankshaft 2 is put on the crank angle location of the request for the next starting by braking or accelerating a crankshaft in an engine starting phase with the electric machine means 4. In order to make it change of the starting angle which is not desirable by the next starting not take place, under an engine shutdown can repeat steps S2 and S3 in succession. If the starting command which starts the starting process of a proper is executed by step S4, an internal combustion engine's 1 crankshaft 2 will be driven even to predetermined starting speed with the electric machine means 4 at step S5. At continuing step S6, an internal combustion engine (after progress of a typical starting period) 1 starts. A starting period can be first kept until a fuel is injected among steps S5 and S6 in the case of the internal combustion engine of direct injection. Namely, an internal combustion engine 4 drives without mixing of a fixed period and a fuel behind further depending on the case until he reaches starting speed.

[0031]

It is step S1, and in the deformation approach of drawing 4 , the command for adjusting on a desired starting square begins just before initiation of the following starting process, and it is given. By automobile, the trigger of this can be carried out by opening a central lock, for example. In addition to this with this deformation gestalt, the capacitor capacitor 10 is used as an energy storage machine for all or a part of energy required for the drive of a starter. Therefore, if a trigger is carried out by the accommodation command at step S1, in the case of the engine shutdown covering long duration, the capacitor capacitor 10 will especially be charged from a dc-battery 9 for the following starting process (step S2). The charge threshold of the capacitor capacitor 10 required for positive starting can also be chosen according to engine temperature and/or an outside temperature. S7 corresponds to S6 from step S2 of the approach of drawing 3 substantially from continuing step S3. This approach is changed only in that all or a part of energy required for the drive of the electric machine means 4 at step S6 comes from the capacitor capacitor 10.

[Brief Description of the Drawings]

[Drawing 1]

It is the schematic diagram of starter system and an internal combustion engine.

[Drawing 2]

It is the outline graph which shows change of the engine speed to a four-cycle internal combustion engine's crank angle.

[Drawing 3]

It is the flow chart of the 1st deformation approach for starting an internal combustion engine.

[Drawing 4]

It is the flow chart of the 2nd deformation approach for starting an internal combustion engine.

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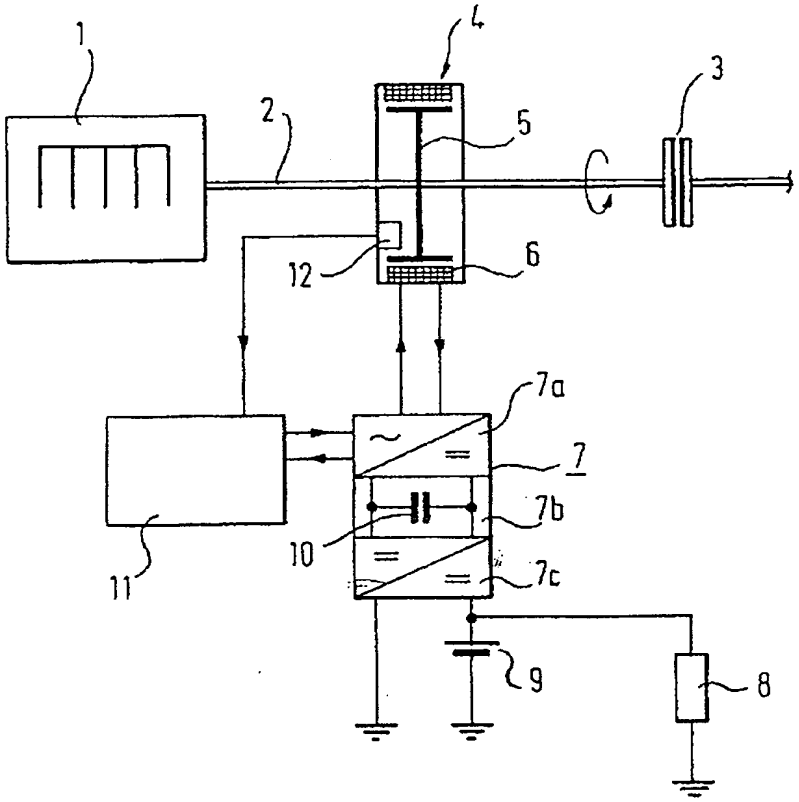
DRAWINGS

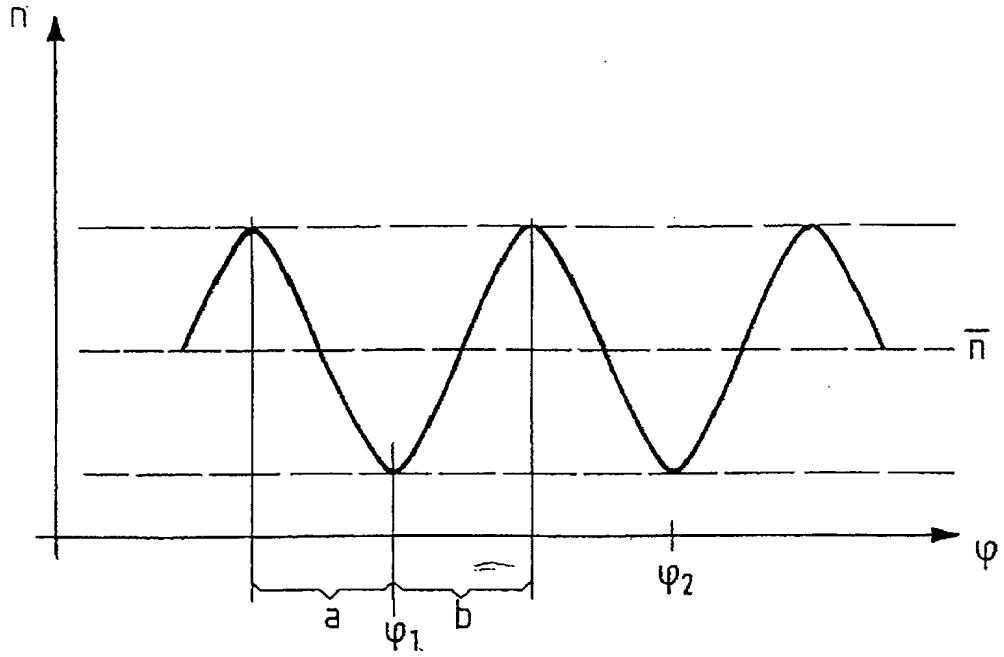
[Drawing 1]

Fig. 1

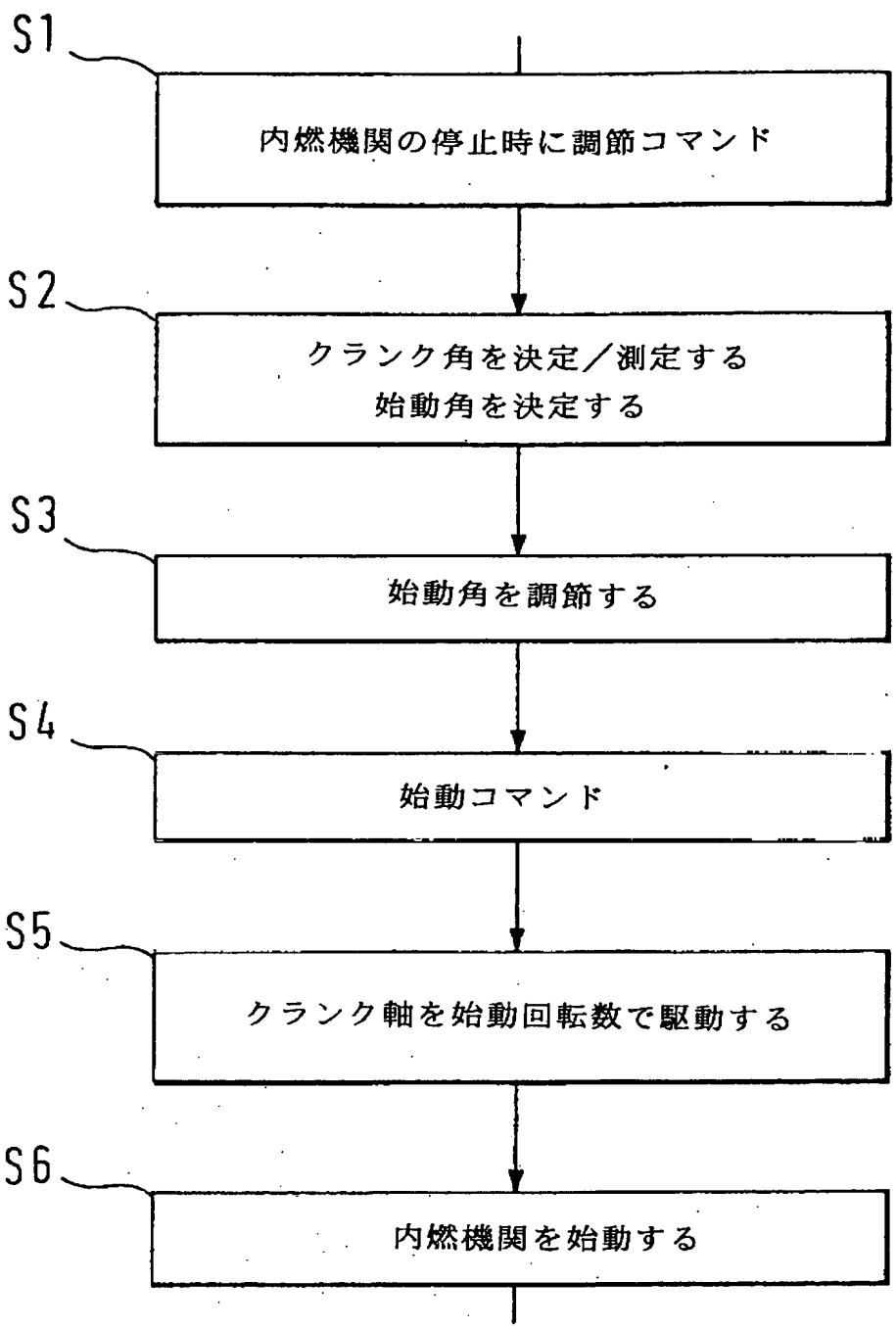


[Drawing 2]

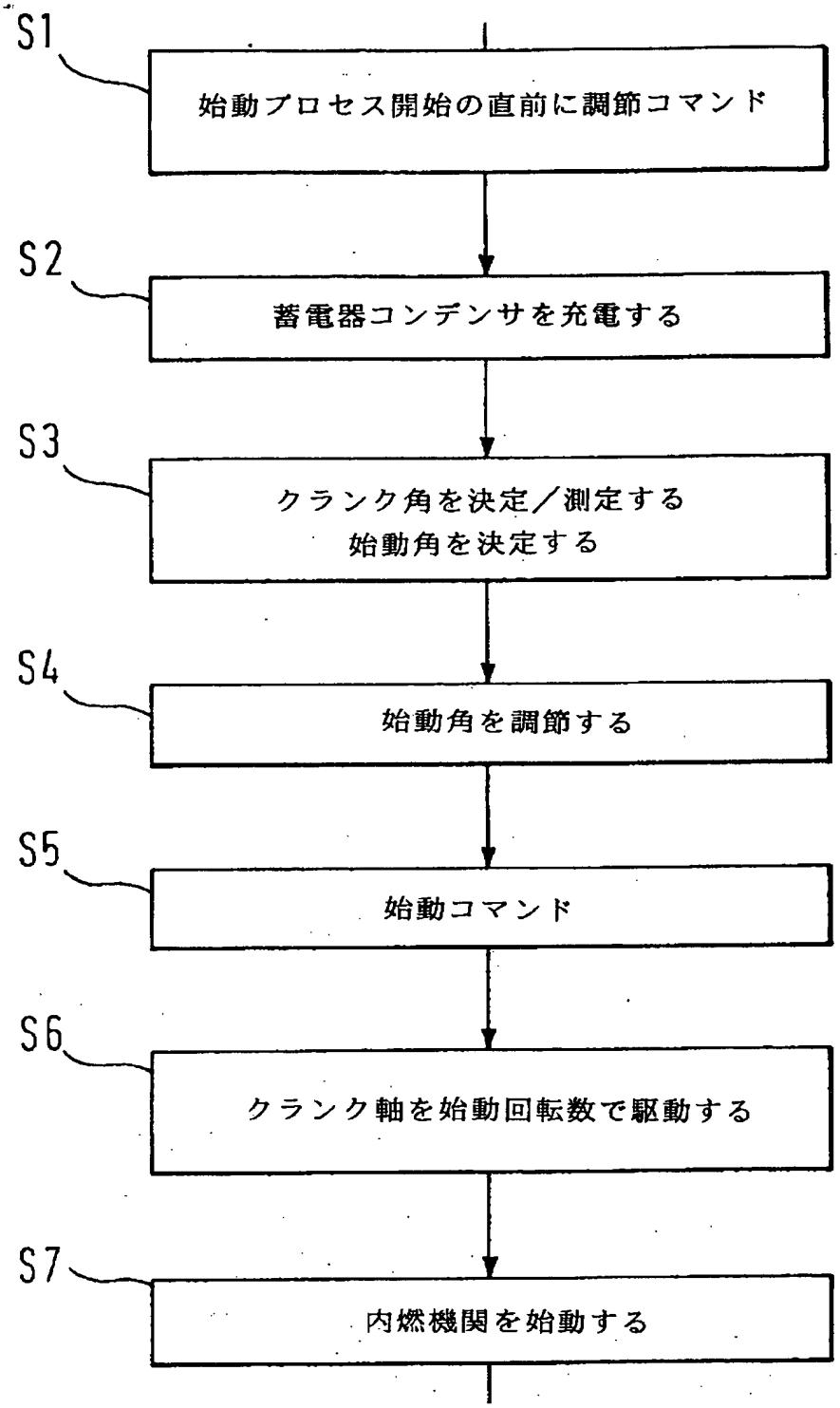
Fig. 2



[Drawing 3]


S1
内燃機関の停止時に調節コマンド
S2
クランク角を決定／測定する
始動角を決定する
S3
始動角を調節する
S4
始動コマンド
S5
クランク軸を始動回転数で駆動する
S6
内燃機関を始動する

[Drawing 4]



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